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ABSTRACT

The memory model, based on information theory proposed by Moser (see SE 013 578), was used to compare the cognitive processing patterns of second and eighth grade Negro and Caucasian students in solving the "parallel circuits" problem. (Connecting two light bulbs and a dry cell so that when both bulbs light, one bulb can be unscrewed, leaving the other lit.) Fifteen male and fifteen female students of each race were randomly selected from each grade level. After the problem was verbally explained, the sequence of connections made by each student was coded. The data processed by successful and unsuccessful students of each race and sex were analyzed separately in terms of Moser's model. Contingency table analyses, t-tests and regression analyses of the parameters of the model were made. All successful students processed most of the information in the short-term memory and showed more long-term memory retrieval than unsuccessful students. The relative number of successful solutions did not differ with respect to race or sex. The information flow patterns found in this study were similar to other examples of problem solving analyzed in terms of the Moser model and were characterized by high noise levels in the information channels. Full data for the calculated "information values" are appended. A glossary containing information theory terms and definitions of the model parameters is also appended. (AL)

INFORMATION PROCESSED BY NEGRO AND CAUCASIAN CHILDREN ENGAGED IN PROBLEM-SOLVING TASKS

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INTRODUCTION

A scientific approach to the phenomenon of human cognition has been developing over the past five years at the University of Pittsburgh under the direction of Dr. Gene W. Moser. Interactions between inputs and outputs of diverse informational experiences have been analyzed and results of these analyses lead one to believe that there may be an underlying basic structure to cognition (1,2). Concepts developed by communication engineers have made this survey of minds in the process of experiencing possible (3). Thus, a hybrid field of knowledge wherein systems theoretical analysis has joined hands with learning theory has emerged. Though this hybridization cannot supply an instantaneous success formula, the application of which would relieve existing educational controversies, it is hoped that it will offer new insights and suggest innovative approaches to those involved in education.

This particular paper, an investigation of the problem-solving behaviors of Negro and Caucasian students, hopes to carry the evolution of a theory of cognition one step further as it attempts to quantitatively describe aspects of a racial group's information processing environment. It is hypothesized that even though degrees of problem accomplishment may be similar for the two groups, the various patterns of information flow in the operating systems could be self organizing along different routes. Perhaps, in this light,

Jensen's (4) claim that underprivileged black preschool children could have failed the Head Start program due to differences between black and white academic performance and ability, differences that he said reflected genuine genetic differences between the two races, would have to be changed to read that blacks had failed because the Head Start program did not emphasize those aspects of the learning environment that would have been most beneficial to their information processing systems.

It is hoped that these same information theoretic measures used to analyze two racial groups could be further applied to the analysis of problem-solving behaviors in the individual child and to the development of learning environments most beneficial to this child. At this point in time, however, when individualization of the entire educational system is not yet a reality, a view of problem-solving as presented here, could show educators that different overall self-stabilization patterns are employed as members of a racial group engage in problem-solving behaviors. Therefore different learning experiences would be deemed necessary to best enhance the efficiency of each group's information processing system.

STATEMENT OF THE PROBLEM

The study developed in this paper will attempt to answer the following question: How can information theory provide us with a model that could be used to systematically investigate problem-solving processes that occur among various racial groups? More specifically, the problem will explore the potential of an information theoretic model used in the analysis of the overt responses of male and female Negro and Caucasian students in grades 2 and 8 as these students physically manipulate an electric circuit problem.

PROCEDURE

The sample was drawn from a population of second and eighth grade students enrolled in a suburban public school district in North Carolina. Both grade levels were represented by 30 Negro and 30 Caucasian subjects chosen from middle income range families. Each racial group consisted of 15 males and 15 females whose names were selected by employing random number tables. It was necessary to choose subjects that were free from the following handicaps: mental retardation, emotional disturbance, severe vision problems, or lack of manipulatory skills necessary to solve the problem. If any of the children drawn at random did not fall within the desired income range or if they possessed any of the listed handicaps, they were not included in the study. Other children were drawn at random to replace any eliminated subjects.

Subjects chosen were expected to physically manipulate an electric circuit problem. The problem-solving sessions were conducted in quiet, well-lighted rooms of the participating schools that afforded adequate working space. The components of the problem, one one and one-half volt dry cell, one single throw switch, two miniature light receptacles (with bulbs) and five 18 inch blue wires with alligator clips at each end were randomly arranged on a large table. Both light bulbs were placed in the receptacles, but they were left partially unscrewed. The switch was left open.

The researcher identified in the following order each component of the problem by pointing to it and saying: "This is a battery; this is a switch; these are two miniature lights, and these are five wires that have alligator clips at each end." The researcher then said: "I would like you to put these materials together so that both bulbs light up and so that when both bulbs

are lit you can unscrew one bulb and still have the other bulb remain lit." Following these instructions, the researcher took one of the five wires and said to the subject (while demonstrating at the same time): "These alligator clips can be placed on these two posts of the battery; they can be placed on these two posts of the switch; and they can be placed on these two posts of the lights." The problem instructions were then repeated. The researcher asked the student if he understood the instructions. If the student answered "yes", the researcher said: "Tell me what you are going to try to do." If the student answered "no", the researcher repeated the same instructions very slowly then asked the student: "What are you going to try to do?" If a student was unable to comprehend the desired state of affairs, he was eliminated and another subject was randomly drawn. If a student was not able to manipulate the alligator clips, i.e. he could not open them, he was also eliminated and another subject randomly drawn. Each student was allowed 15 minutes working time. If successful, he was dismissed earlier and his problem-solving time was recorded.

The researcher recorded the various connections made by each student by placing coded symbols (a total of eight symbols were chosen to represent the connection terminals) onto sheets of tablet paper. Any connections dismantled before a test was made were circled. A test was defined as a situation in which the subject got both bulbs to light and he, in turn, unscrewed one bulb to see if the other still remained lit. Following a test situation, wire connections from the preceding code sequence that were not disconnected were recorded as the first connections of the new code sequence.

In order to analyze the various codes obtained it was necessary to classify data into the following categories, codes processed by unsuccessful

and successful students, by unsuccessful and successful male and female students, by unsuccessful and successful male and female students, by unsuccessful and successful Negro and Caucasian students, by unsuccessful and successful male Negro and female Negro students, and by unsuccessful and successful male Caucasian and female Caucasian students. A total of 18 categories was thereby established for each of grades two and eight.

Codes from each of these categories were then transferred to eight by eight matrices. Letters "A" through "H" were used to label the rows and columns of the matrices. These letters represented the various components of the problem. The battery terminals were represented by "A", the positive terminal, and "B", the negative terminal. The letters "C" and "D" represented the poles of the switch. The "D" pole had a strip of yellow paint along its side to allow the observer to distinguish it from the "C" pole. The poles of the light receptacles were represented by "E", "F", "G", and "H". The "F" pole (a gold pole) of one light receptacle had a strip of black paint along its side. The other pole of this light receptacle, "E" (a silver pole) had no markings. The "G" pole of the other light receptacle was a gold pole and the "H" pole a silver pole. No markings were placed on this light receptacle.

Each matrix obtained represented the grand total of various connections made by students in each of the categories listed. Information measures were calculated directly from these matricies. These measures along with their definitions are listed in Appendix II.

RESULTS

Information measures were calculated directly from matricies showing the frequencies of various connections made by successful and unsuccessful student groups in grades 2 and 8. These measures along with their definitions are listed in Appendix II. Information values obtained from actual data analyses are summarized in Tables I through XI of Appendix I. It will be noted that no values are listed for the grade 2 successful groups. Herein, two students (one Negro male who made 19 connections and one Caucasian male who made 5 connections) did succeed but their connections were not analyzed due to the fact that they did not afford the variety of actions that would permit calculating the complete repertoire of information values. Chi-square tests, t-tests and regression analyses were employed to determine the significances of differences between the various information measures obtained.

Finding: 01

All student groups solving the parallel circuit problem processed their greater amounts of information in the short term memory. Successful problem solutions, however, showed more long term memory retrieval than did unsuccessful solutions.

Analyses of long term memory values involved treatment of data in the original and in the steady state matrix to determine differences between the information content of an input alligator clip connection and the useful amount of information flowing between two consecutive alligator clip connections. Long term memory measures in all cases decreased going from the original to the steady state matrix (see Tables I-XI). This decrease of long term memory information from dependent actions to independent actions indicated that student groups were not drawing primarily upon previously stored experiences to solve

the problem and that the input information was being processed to a greater extent in the short term memory. This finding was also reported in another study by Moser (8). Chi-square analyses of group long term memory values in the memoryful condition (Table XIV) showed no significant differences. Since these values represented activity in the short term memory, it was concluded that all groups processed similar amounts of information in their short term memories. Significant chi-square values were obtained from the analyses of differences between amounts of information processed in long term memories (Table XV). Herein, these values were greater than expected for successful problem solutions and less than expected for unsuccessful solutions. Successful groups were able, therefore, to significantly increase amounts of information processed in their long term memory store. Reference to Table XII which shows differences between amounts of information processed in long term memories for successful and unsuccessful student groups shows that in the case of Negroes, especially female Negroes, a marked difference existed in the ability of successful and unsuccessful groups to retrieve information from their long term memories. It is conjectured that this increased ability to draw from the long term memory store displayed by the successful Negro group, again emphasizing the female Negro group, was a primary factor in determining problem outcome for these groups.

Finding: 02

The useful information processed in the problem-solving experience varied as to subjects' grade level, sex, race and problem-outcome.

The REAL information measure, as proposed in the memory model described elsewhere in this seminar (8), is defined as the useful information flowing in a channel. It is a component which describes the "amount" of useful information

shared between consecutive X and Y messages stored either in the short term memory store or in the long term memory store. The secondary REAL information measure is % REAL, or the proportion of the transmission channel which is of useful information.

Significant chi-square values were obtained for the information flowing in channels in the memoryful and memoryless conditions. The second grade groups obtained significant results in both conditions whereas only the latter condition had significant differences of channel flow processed by eighth grade groups. The second grade male and female groups of Negroes had greater than expected proportions of useful information flowing in both levels of channels. Less than expected amounts of REAL factors were flowing in actions processed by the Caucasian groups.

The chi-square test results (Table XVI and XVII) were quite different in interpretative relationships for the flow of useful information for eighth grade subjects solving the parallel circuit problem. The successful group of solvers had a greater than expected REAL information factor in the memoryless condition. The group of successful females and the group of males who failed to solve the problem also had greater than expected proportions of their channel occupied by REAL information.

Finding: 03

Channel limits for error capacity operated at significantly different levels for successful eighth grade subjects grouped according to sex and race. Significant coefficients of correlation were found for error capacities of groups of unsuccessful students but not for groups of successful students.

When problem-solvers receive information from the environment they scan this information for identification and for possible filtration into a CODE signal. These two processes are outlined in the Moser memory model (8)

developed in a paper presented at this NARST conference. One component of this model, the error correction information component, is that component which "operates" on input information. The capacity of a channel, a partial function of the ratio of the error connection information to the input information, can be expressed as: $H(X)/H_y(X)$. According to Shannon (3), there are levels of input information above which encoding cannot be achieved for effective transmission. The electric circuit problem data were treated to determine the levels of channel error capacity and the limits for these channels.

The error capacity limits for transmission channels differ in the memoryful and memoryless conditions of information processing. The differences of the ratio values are shown in Table XVIII. A range of 1.2507 to 1.9376 bits of input information is treated per bit of error correction information in the memoryful condition. The amount of input information per correction bit decreaces to an average of 1.0321 bits at the memoryless level. These differences are due to changes in the channel error limits. Larger amounts of input information are "tolerated" in a memoryful condition where the consecutive X and Y messages are "related" to each other. Then, as the memoryless condition ensues and there is little or no "relatedness" of X and Y messages, the amount of input information per error correction information bit approaches unity. This is seen as meaning that more error correction information is needed for the channel.

The differences between the ratios for memoryful and memoryless conditions are shown in Table XVIII. These are identified as changes in the levels of error limits. The successful eighth grade groups of subjects differed from the unsuccessful groups. As shown in Table XVIII, the successful groups had greater ranges of change in amounts of input information per error correction information

bit. This range is a function of the error limit capacity in the processing of the information received from the environment. Chi-square tests were calculated for changes in error limits found for groups of second and eighth grade subjects. Significant values were obtained for successful eighth grade students grouped according to sex and race. The male Caucasian group had a change of error capacity which was less than expected. On the other hand, the female Negro and Caucasian groups, and the Negro male group had change levels which were greater than expected for the successful processing of the electric circuit problem.

Regression analyses were done for clusters of subgroups of problem-solvers. The clusters were of the eight subgroups of second and eighth grade subjects who failed to solve the problem. No significant coefficients of correlation were found for the test of the first cluster of subgroups. That is the H(X) was not found to be significantly correlated with the $H_y(X)$ information measured. These memoryful and memoryless condition coefficients were 0.5877 and 0.4524. The lack of relationship between the input and error correction information measures can be attributed to aforementioned results of chi-square tests. There seems to be a difference in error limit capacities for the two sets of subgroups of eighth grade subjects whose values of information were used in the cluster. These sets were the successful and unsuccessful groups and their limit values are apparently of different function levels (see Table VIII. The second cluster was found to have significant correlations for H(X) and $H_y(X)$. The coefficients were 0.7609 and 0.9998 for the memoryful and memoryless conditions. The X intercept estimates for these respective conditions were 2.7867 and 2.0000 bits. These values indicate the level of input information at which there is no error correction information and above

which there is a relationship for the "application" of error correction information to the received information. An interpretation of these findings are continued in the conclusion section.

Finding: 04

Groups successfully processing the electric circuit problem exhibited greater strengths of dependence between consecutive alligator clip connections than did groups unsuccessfully processing the problem.

A measure of the strength of dependence between first and second alligator clip connections was obtained by employing equations derived to determine the matrix power which approximates steady state conditions. The validity of these equations was tested by driving sets of science dialogue matrix probability values to steady state on a computer (i.e. by raising these values to higher powers) and by comparing computer steady state levels to levels obtained by using the equations.

Strength of dependence between the act of processing first and second alligator clip connections was considered to be a measure of the degree of coherence operating between these two cognitive events. Thus, if a set of events becomes independent at a lower matrix power than another set of events, that set is considered to possess a lower strength of dependence and to be less coherent. Reference to Tables I through XI shows that in the electric circuit problem successful eighth grade student groups processed information with a greater strength of dependence operating than did unsuccessful groups (the only exceptions being the male group and the male Caucasian group wherein the unsuccessful operated with a slightly greater degree of coherence than did the successful). This coherence factor appeared to contribute significantly to the outcome of female problem-solvers for in the case of the female , the

female Negro and the female Caucasian groups large differences were apparent in dependence behavior values of successful and unsuccessful problem processing.

Finding: 05

The groups of second and eighth grade subjects who failed to solve the electric circuit problem were found to differ from each other in the amounts of LTM information processed in both the memoryful and memoryless conditions and in the amounts of changed error limit capacity.

The three above listed information measures have been discussed in the aforementioned findings. Chi-square tests of these information measures were calculated with respect to the groups of subjects in grades two and eight who had failed to solve the problem.

The chi-square results for female Negro and female Caucasian groups in grades 2 and 8 were not found to be significantly different. These tests were for the LTM measures and error limit capacity.

The chi-square test results were found to be significant for males of the Negro and Caucasian races. In every test the differences of observed and actual values had the same levels of distribution with respect to race and grade level. The second grade male Caucasian group processed more LTM information than expected at both the memoryful and memoryless levels. The same was found for the level of error limit capacity. On the other hand, the eighth grade male Negro group processed greater than expected amounts of LTM memoryful and memoryless information. They also had a greater than expected error limit capacity. These findings also indicate that the second grade male Negro and eighth grade male Caucasian groups processed these same kinds of information in less than the expected amounts.

Finding: C6

The relative numbers of subjects who successfully or unsuccessfully solved the electric circuit problem did not significantly differ from each other with respect to sex or race characteristics. There were, however, significant differences in the mean number of wire connections made in the processing of the problem.

The numbers of subjects who failed or succeeded in solving the electric circuit problem are listed in Table X[illegible]. Chi-square tests for these frequencies were not found to be significant. These results are shown in Table XIX. This finding indicated there were no sex or race differences for potential success in solving the problem. It also enabled the author to statistically test for information measure differences with respect to the distribution of subjects by the group characteristics. That is, no differences in success and failure potentials and in race or sex groups enabled the use of non-biased frequency ranges in the contingency kind of chi-square tests.

The subjects who participated in the study each had five electric wires available for completing the parallel circuit. Other than the number of available wires, the subjects were not constrained in the number of connections which could be made in the problem. The mean number of connections made by groups of subjects are shown in Table XX. The t-test was applied and it was found to be significant at the five per cent level. The mean number of connections made differed significantly for successful and unsuccessful groups of eighth graders. There was a tendency for students who failed to have made more connections than students who succeeded. When differences were applied, according to sex and race, it was found that Negro groups of females and males tended to make fewer connections than did Caucasian groups.

CONCLUSION

There have been several studies to determine how humans solve the parallel electric circuit problem (2,8). These studies used an information theoretic memory model to define the flow of information in the problem-solving task. They have never, however, examined differences in information processing that may exist for racial groups of children. This paper describes a study to establish those differences in information processing.

There are 18 primary and secondary components to the memory model used in this study. These are described in Appendix II. The design of the analysis was to determine the information values for the task processes of each of the racial groups in grades 2 and 8. All of the 28 second grade children failed to solve the problem. Almost two-fifths of the group of eighth grade students solved the problem. There were no significant differences in the chances of success obtained for racial groups. The same level of probability was also found for the sexes of the racial groups.

The information flow for solving the electric circuit problem is quite familiar to us. It is a problem-solving cognitive task and as was found in other studies (2,8) had high noise levels in transmission channels. The amounts of LTM measure found in this task were also similar to those found in other studies. Ranges in previous studies were 0.137 to 0.258 bit; in this study it was 0.264 to 0.357 bit. Reference to other information theoretic studies of problem-solving (2,8) revealed several other similarities in information values. Tables I through XI in Appendix I contain all information values calculated in this study.

There were few differences between groups of Negro and Caucasian children with respect to the processing of the electric circuit problem. A considerable number of statistical tests were applied to the information measures to support this claim. There were no significant differences in the chances for success in the problem task. The Caucasian groups made significantly greater mean numbers of electric wire connections. The differences in information processing were found to be relatively small in number and to be as distinguishable for sex groups as for racial groups. It was found that the group of female Negro eighth grade children succeeded in solving the problem because they processed more useful information in the memoryful and memoryless conditions. They also utilized greater amounts of LTM information in the long term memory store and had a greater level of tolerance for change in the error limits of the transmission channel. The same characteristic of operating error limits partially accounted for the success of the female Caucasian group of eighth grade children. Both groups of female children processed more than an expected amount of useful information in successfully solving the problem.

The eighth grade groups of male subjects succeeded through operating a greater strength of dependence between messages than that occurring for those who failed to solve the problem. The successful male Negro group of students processed a greater than expected mean number of electric wire connections and, like the female group, had a greater tolerance for change in channel error limits. The second grade group of male Negro children were quite like the eighth grade group of females in that they processed tasks with greater than expected amounts of useful information flowing in the memoryful and memoryless channels.

The potential for successfully solving the problem, irrespective of characteristics of children, was mainly due to differences in the use of the LTM information measure in the long term memory store and to differences in the ratio of the flow of useful information in that condition of the memory. In addition the tolerance of ranges in error limit capacities played a role in successfully solving the problem.

The major indicators of memory component actions by groups of students who failed to solve the problem were found to contrast with the above mentioned information measures. Failure by both second and eighth grade groups of children was distinguished by the fact that these groups processed greater than expected amounts of LTM information in both the memoryful and memoryless conditions. This tendency characterized male student groups but not female groups. The difference between grade levels was that in every case the second grade male Caucasian group and the eighth grade Negro group processed greater than expected amounts of LTM information. The reader should note that problem-solving failure was related to amounts of LTM information whereas success was more related to ratios and proportions of LTM information. In contrast to this difference of processing, the control of input information played another role in the potential for successful solutions of the electric circuit problem. A regression analysis of the correspondence of input to error correction information was found to be of a direct relationship only with respect to the unsuccessful solution of the problem. This conclusion is believed to be quite related to the above mentioned ranges of tolerance for error limit capacities in channels.

As Menzel pointed out at the Wingspread Conference: "Little is known to date about what may be called the culture of information seeking." (9) The

reader may feel that this paper has attempted to emphasize Menzel's mention of culture and that the author has hoped to uncover statements that could describe how members of a particular racial group adjust to a problem-solving environment. in ways that are, perhaps, more efficient than those displayed by members of another racial group. Such a view would be most detrimental to the advancement of the cognition theory supported in this paper. It must be emphasized that when the author began this experimental design, she proceeded upon the premise that no differences in degree of problem outcome would be operating among Negro and Caucasian groups. Acceptance of this hypothesis was critical to further information theoretic analyses that followed. It also allowed the researcher to present to the educational community a basis for questioning claims made by Jensen (4) and reports presented by the National Assessment of Educational Progress (10). If different racial groups are, indeed, equipped with equal potential and if our present educational system is not developing these potentials to equal degrees, it does not seem that the fault lies with information processors. These processors who are constantly being exposed to environmental stimuli and who have available repertoires of past experiences that somehow influence response alternatives must be viewed in a way that will maximize our understanding of their selection, response and interpretation of information. The Moser memory model has attempted this. On the surface it may appear as a most complex mathematical webb, but slowly and steadily we are pulling at its delicate underlying structures only to find simple, self-evident relations that may be the threadlike networks that comprise man's cognitive systems.

APPENDIX I

TABLE I

A SUMMARY OF INFORMATION VALUES CALCULATED FOR UNSUCCESSFUL STUDENTS IN GRADE 2

Information Measure	M^1*	S.S.**	Change***
H(X)	2.9885	2.9885	
R.E.	99.62%		
$H_x(Y)$	2.6537		
R.E.	88.46%		
CODE	0.3348		
CODE EFFICIENCY	11.20%		
H(Y)	3.2532	3.0115	0.2417
$H_y(X)$	2.3890	2.9655	0.5765
REAL	0.5995	0.0230	0.5765
% REAL	10.63%	0.38%	10.25%
LTM	0.2647	0.0230	0.2417
% LTM	44.15%		
H(X,Y)	5.6422	5.9770	0.3348
NOISE	5.0427	5.9540	0.9113
% NOISE	89.37%	99.62%	10.25%
NOISE in X	79.94%	99.23%	19.29%
NOISE in Y	81.57%	99.24%	17.67%
Cells Occupied	60	64	
% Occupancy	93.75%		
Log_2 N	5.9069	6.0000	
Variety	8		
Adjusted CODE M^1	0.31387500		
M^2	0.09851752		
M^4	0.00970570		
M^{16}	0.00009420		
M^{256}	0.00000001		

*Value in original matrix.
**Value at Steady State matrix.
***Change, M^1 - S.S.

TABLE II

A SUMMARY OF INFORMATION VALUES CALCULATED ACCORDING TO SEX
FOR UNSUCCESSFUL STUDENTS IN GRADE 2

	MALE			FEMALE		
Information Measure	M1	S.S.	Change	M1	S.S.	Change
H(X)	2.9715	2.9715		2.9632	2.9632	
R.E.	99.05%			98.77%		
$H_X(Y)$	2,5958			2.4092		
R.E.	86.53%			80.31%		
CODE	0.3757			0.5540		
CODE EFFICIENCY	12.64%			18.70%		
H(Y)	3.3111	3.0285	0.2826	3.3982	3.0368	0.3614
$H_Y(X)$	2.2562	2.9145	0.6583	1.9742	2.8896	0.9154
REAL	0.7153	0.0570	0.6583	0.9890	0.0736	0.9154
% REAL	12.85%	0.96%	11.89%	18.41%	1.24%	17.17%
LTM	0.3396	0.0570	0.2826	0.4350	0.0736	0.3614
% LTM	47.48%			43.98%		
H(X,Y)	5.5673	5.9430	0.3757	5.3724	5.9264	0.5540
NOISE	4.8520	5.8860	1.0340	4.3834	5.8528	1.4694
% NOISE	87.15%	99.04%	11.89%	81.59%	98.76%	17.17%
NOISE in X	75.93%	98.08%	22.15%	66.62%	97.52%	30.90%
NOISE in Y	78.40%	98.12%	19.72%	70.90%	97.58%	26.68%
Cells Occupied	60	64		56	64	
% Occupancy	93.75%			87.50%		
$\log_2 N$	5.9069	6.0000		5.8074	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.35221875			0.48475000		
M^2	0.12405805			0.23498256		
M^4	0.01539040			0.05521680		
M^{16}	0.00023686			0.00304890		
M^{256}	0.00000006			0.00000930		

TABLE III

A SUMMARY OF INFORMATION VALUES CALCULATED ACCORDING TO RACE FOR UNSUCCESSFUL STUDENTS IN GRADE 2

	NEGRO			CAUCASIAN		
Information Measure	M^1	S.S.	Change	M^1	S.S.	Change
H(X)	2.9837	2.9837		2.9671	2.9671	
R.E.	99.46%			98.90%		
$H_x(Y)$	2.5881			2.4747		
R.E.	86.27%			82.49%		
CODE	0.3956			0.4924		
CODE EFFICIENCY	13.26%			16.60%		
H(Y)	3.2448	3.0163	0.2285	3.4322	3.0329	0.3993
$H_y(X)$	2.3270	2.9511	0.6241	2.0096	2.9013	0.8917
REAL	0.6567	0.0326	0.6241	0.9575	0.0658	0.8917
% REAL	11.79%	0.55%	11.24%	17.60%	1.11%	16.49%
LTM	0.2611	0.0326	0.2285	0.4651	0.0658	0.3993
% LTM	39.76%			48.57%		
H(X,Y)	5.5718	5.9674	0.3956	5.4418	5.9342	0.4924
NOISE	4.9151	5.9348	1.0197	4.4843	5.8684	1.3841
% NOISE	88.21%	99.45%	11.24%	82.40%	98.89%	16.49%
NOISE in X	77.99%	98.91%	20.92%	67.73%	97.78%	30.05%
NOISE in Y	79.76%	98.92%	19.16%	72.10%	97.83%	25.73%
Cells Occupied	57	64		60	64	
% Occupancy	89.06%			93.75%		
Log_2 N	5.8329	6.0000		5.9069	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.35232136			0.46162500		
M^2	0.12413034			0.21309764		
M^4	0.01540834			0.04541060		
M^{16}	0.00023742			0.00206212		
M^{256}	0.00000006			0.00000425		

TABLE IV

A SUMMARY OF INFORMATION VALUES CALCULATED ACCORDING TO SEX AND RACE FOR UNSUCCESSFUL STUDENTS IN GRADE 2

Information Measure	MALE-NEGRO M^1	MALE-NEGRO S.S.	MALE-NEGRO Change	MALE-CAUCASIAN M^1	MALE-CAUCASIAN S.S.	MALE-CAUCASIAN Change
H(X)	2.9742	2.9742		2.9348	2.9348	
R.E.	99.14%			97.83%		
$H_x(Y)$	2.6183			2.2767		
R.E.	87.28%			75.89%		
CODE	0.3559			0.6581		
CODE EFFICIENCY	11.97%			22.42%		
H(Y)	3.2146	3.0258	0.1888	3.5562	3.0652	0.4910
$H_y(X)$	2.3779	2.9226	0.5447	1.6553	2.8044	1.1491
REAL	0.5963	0.0516	0.5447	1.2795	0.1304	1.1491
% REAL	10.66%	0.87%	9.79%	24.55%	2.22%	22.33%
LTM	0.2404	0.0516	0.1888	0.6214	0.1304	0.4910
% LTM	40.32%			48.57%		
H(X,Y)	5.5925	5.9484	0.3559	5.2115	5.8696	0.6581
NOISE	4.9962	5.8968	0.9006	3.9320	5.7392	1.8072
% NOISE	89.34%	99.13%	9.79%	75.45%	97.78%	22.33%
NOISE in X	79.95%	98.27%	18.32%	56.40%	95.56%	39.16%
NOISE in Y	81.45%	98.29%	16.84%	64.02%	95.75%	31.73%
Cells Occupied	57	64		57	64	
% Occupancy	89.06%			89.06%		
Log_2 N	5.8329	6.0000		5.8329	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.31696454			0.58610386		
M^2	0.10046652			0.34351773		
M^4	0.01009352			0.11800443		
M^{16}	0.00010188			0.01392505		
M^{256}	0.00000001			0.00019391		
Error Limit Input	1.2507	1.0176	0.2331	1.7729	1.0464	0.7265

TABLE IV (continued)

Information Measure	FEMALE-NEGRO M^1	S.S.	Change	FEMALE-CAUCASIAN M^1	S.S.	Change
H(X)	2.9783	2.9783		2.8944	2.8944	
R.E.	99.28%			96.48%		
$H_x(Y)$	2.3125			2.0922		
R.E.	77.08%			69.74%		
CODE	0.6658			0.8022		
CODE EFFICIENCY	22.36%			27.72%		
H(Y)	3.3599	3.0217	0.3382	3.4928	3.1056	0.3872
$H_y(X)$	1.9309	2.9349	1.0040	1.4938	2.6832	1.1894
REAL	1.0474	0.0434	1.0040	1.4006	0.2112	1.1894
% REAL	19.80%	0.73%	19.07%	28.09%	3.65%	24.44%
LTM	0.3816	0.0434	0.3382	0.5984	0.2112	0.3872
% LTM	36.43%			42.72%		
H(X,Y)	5.2908	5.9566	0.6658	4.9866	5.7888	0.8022
NOISE	4.2434	5.9132	1.6698	3.5860	5.5776	1.9916
% NOISE	80.20%	99.27%	19.07%	71.91%	96.35%	24.44%
NOISE in X	64.83%	98.54%	33.71%	51.61%	92.70%	41.09%
NOISE in Y	68.83%	98.56%	29.73%	59.90%	93.20%	33.30%
Cells Occupied	51	64		48	64	
% Occupancy	79.69%			75.00%		
Log_2 N	5.6724	6.0000		5.5850	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.53057602			0.60165000		
M^2	0.28151091			0.36198272		
M^4	0.07924839			0.13103149		
M^{16}	0.00628031			0.01716925		
M^{256}	0.00003944			0.00029478		
Error Limit Input	1.5424	1.0147	0.5277	1.9376	1.0787	0.8589

TABLE V

A SUMMARY OF INFORMATION VALUES CALCULATED
FOR SUCCESSFUL AND UNSUCCESSFUL STUDENTS IN GRADE 8

Information Measure	SUCCESSFUL M^1	S.S.	Change	UNSUCCESSFUL M^1	S.S.	Change
H(X)	2.9595	2.9595		2.9881	2.9881	
R.E.	98.65%			99.60%		
$H_x(Y)$	2.4914			2.5728		
R.E.	83.05%			85.76%		
CODE	0.4681			0.4153		
CODE EFFICIENCY	15.82%			13.90%		
H(Y)	3.3160	3.0405	0.2755	3.3098	3.0119	0.2979
$H_y(X)$	2.1349	2.8785	0.7436	2.2511	2.9643	0.7132
REAL	0.8246	0.0810	0.7436	0.7370	0.0238	0.7132
% REAL	15.13%	1.37%	13.76%	13.25%	0.40%	12.85%
LTM	0.3565	0.0810	0.2755	0.3217	0.0238	0.2979
% LTM	43.23%			43.65%		
H(X,Y)	5.4509	5.9190	0.4681	5.5609	5.9762	0.4153
NOISE	4.6263	5.8380	1.2117	4.8239	5.9524	1.1285
% NOISE	84.87%	98.63%	13.76%	86.75%	99.60%	12.85%
NOISE in X	72.14%	97.26%	25.12%	75.34%	99.20%	23.86%
NOISE in Y	75.13%	97.34%	22.21%	77.73%	99.21%	21.48%
Cells Occupied	56	64		59	64	
% Occupancy	87.50%			92.19%		
Log_2 N	5.8074	6.0000		5.8826	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.40958750			0.38286507		
M^2	0.16776192			0.14658566		
M^4	0.02814406			0.02148736		
M^{16}	0.00079209			0.00046171		
M^{256}	0.00000063			0.00000021		

TABLE VI

A SUMMARY OF INFORMATION VALUES CALCULATED ACCORDING TO SEX FOR SUCCESSFUL STUDENTS IN GRADE 8

Information Measure	MALE M^1	MALE S.S.	MALE Change	FEMALE M^1	FEMALE S.S.	FEMALE Change
H(X)	2.9609	2.9609		2.9323	2.9323	
R.E.	98.70%			97.74%		
$H_x(Y)$	2.4900			2.1893		
R.E.	83.00%			72.98%		
CODE	0.4709			0.7430		
CODE EFFICIENCY	15.90%			25.34%		
H(Y)	3.3174	3.0391	0.2783	3.3343	3.0677	0.2666
$H_y(X)$	2.1335	2.8827	0.7492	1.7873	2.7969	1.0096
REAL	0.8274	0.0782	0.7492	1.1450	0.1354	1.0096
% REAL	15.18%	1.32%	13.86%	22.36%	2.31%	20.05%
LTM	0.3565	0.0782	0.2783	0.4020	0.1354	0.2666
% LTM	43.09%			35.11%		
H(X,Y)	5.4509	5.9218	0.4709	5.1216	5.8646	0.7430
NOISE	4.6235	5.8436	1.2201	3.9766	5.7292	1.7526
% NOISE	84.82%	98.68%	13.86%	77.64%	97.69%	20.05%
NOISE in X	72.06%	97.36%	25.30%	60.95%	95.38%	34.43%
NOISE in Y	75.06%	97.43%	22.37%	65.66%	95.59%	29.93%
Cells Occupied	56	64		46	64	
% Occupancy	87.50%			71.88%		
Log_2 N	5.8074	6.0000		5.5236	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.41203750			0.53406840		
M^2	0.16977490			0.28522906		
M^4	0.02882352			0.08135562		
M^{16}	0.00083080			0.00661874		
M^{256}	0.00000069			0.00004381		

TABLE VII

A SUMMARY OF INFORMATION VALUES CALCULATED ACCORDING TO RACE FOR SUCCESSFUL STUDENTS IN GRADE 8

	NEGRO			CAUCASIAN		
Information Measure	M^1	S.S.	Change	M^1	S.S.	Change
H(X)	2.8921	2.8921		2.9490	2.9490	
R.E.	96.40%			98.30%		
$H_x(Y)$	2.1908			2.4168		
R.E.	73.03%			80.56%		
CODE	0.7013			0.5322		
CODE EFFICIENCY	24.25%			18.05%		
H(Y)	3.2686	3.1079	0.1607	3.3646	3.0510	0.3136
$H_y(X)$	1.8143	2.6763	0.8620	2.0012	2.8470	0.8458
REAL	1.0778	0.2158	0.8620	0.9478	0.1020	0.8458
% REAL	21.20%	3.73%	17.47%	17.66%	1.73%	15.93%
LTM	0.3765	0.2158	0.1607	0.4156	0.1020	0.3136
% LTM	34.93%			43.85%		
H(X,Y)	5.0829	5.7842	0.7013	5.3658	5.8980	0.5322
NOISE	4.0051	5.5684	1.5633	4.4180	5.7960	1.3780
% NOISE	78.80%	96.27%	17.47%	82.34%	98.27%	15.93%
NOISE in X	62.73%	92.54%	29.81%	67.86%	96.54%	28.68%
NOISE in Y	67.03%	93.06%	26.03%	71.83%	96.66%	24.83%
Cells Occupied	44	64		55	64	
% Occupancy	68.75%			85.94%		
Log_2 N	5.4594	6.0000		5.7814	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.48214375			0.45737268		
M^2	0.23246260			0.20918977		
M^4	0.05403886			0.04376036		
M^{16}	0.00292020			0.00191497		
M^{256}	0.00000853			0.00000367		

TABLE VIII

A SUMMARY OF INFORMATION VALUES CALCULATED ACCORDING TO SEX AND RACE FOR SUCCESSFUL STUDENTS IN GRADE 8

	MALE-NEGRO			MALE-CAUCASIAN		
Information Measure	M^1	S.S.	Change	M^1	S.S.	Change
H(X)	2.9092	2.9092		2.9270	2.9270	
R.E.	96.97%			97.57%		
$H_X(Y)$	2.0853			2.4273		
R.E.	69.51%			80.91%		
CODE	0.8239			0.4997		
CODE EFFICIENCY	28.32%			17.07%		
H(Y)	3.3741	3.0908	0.2833	3.3006	3.0730	0.2276
$H_Y(X)$	1.6204	2.7276	1.1072	2.0537	2.7810	0.7273
REAL	1.2888	0.1816	1.1072	0.8733	0.1460	0.7273
% REAL	25.80%	3.12%	22.68%	16.31%	2.49%	13.82%
LTM	0.4649	0.1816	0.2833	0.3736	0.1460	0.2276
% LTM	36.07%			42.78%		
H(X,Y)	4.9945	5.8184	0.8239	5.3543	5.8540	0.4997
NOISE	3.7057	5.6368	1.9311	4.4810	5.7080	1.2270
% NOISE	74.20%	96.88%	22.68%	83.69%	97.51%	13.82%
NOISE in X	55.70%	93.76%	38.06%	70.16%	95.01%	24.85%
NOISE in Y	61.80%	94.12%	32.32%	73.54%	95.25%	21.71%
Cells Occupied	44	64		53	64	
% Occupancy	68.75%			82.81%		
Log_2 N	5.4594	6.0000		5.7279	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.56643125			0.41380157		
M^2	0.32084436			0.17123174		
M^4	0.10294110			0.02932031		
M^{16}	0.01059687			0.00085968		
M^{256}	0.00011229			0.00000074		
Error Limit Input	1.7953	1.0665	0.7288	1.4252	1.0524	0.3730

TABLE VIII (continued)

Information Measure	FEMALE-NEGRO M^1	S.S.	Change	FEMALE-CAUCASIAN M^1	S.S.	Change
H(X)	2.6512	2.6512		2.9323	2.9323	
R.E.	88.37%			97.74%		
$H_x(Y)$	1.8363			2.0710		
R.E.	71.04%			69.03%		
CODE	0.8149			0.8613		
CODE EFFICIENCY	30.73%			29.37%		
H(Y)	2.8641	2.5187	0.3454	3.3884	3.0677	0.3207
$H_y(X)$	1.6234	2.7837	1.1603	1.6149	2.7969	1.1820
REAL	1.0278	-0.1325	1.1603	1.3174	0.1354	1.1820
% REAL	22.90%	2.50%	20.40%	26.33%	2.31%	24.02%
LTM	0.2129	-0.1325	0.3454	0.4561	0.1354	0.3207
% LTM	20.71%			34.62%		
H(X,Y)	4.4875	5.3024	0.8149	5.0033	5.8646	0.8613
NOISE	3.4597	5.4349	1.9752	3.6859	5.7292	2.0433
% NOISE	77.10%	102.50%	5.40%	73.67%	97.69%	24.02%
NOISE in X	61.23%	105.00%	43.77%	55.07%	95.38%	40.31%
NOISE in Y	64.11%	105.26%	41.15%	61.12%	95.59%	34.47%
Cells Occupied	26	36		44	64	
% Occupancy	72.22%			68.75%		
Log_2 N	4.7004	5.1699		5.4594	6.0000	
Variety	6			8		
Adjusted CODE M^1	0.58852078			0.59214375		
M^2	0.34635671			0.35063422		
M^4	0.11996297			0.12294436		
M^{16}	0.01439111			0.01511532		
M^{256}	0.00020710			0.00022847		
Error Limit Input	1.6331	0.9524	0.6807	1.8157	1.0484	0.7673

TABLE IX

A SUMMARY OF INFORMATION VALUES CALCULATED ACCORDING TO SEX FOR UNSUCCESSFUL STUDENTS IN GRADE 8

	MALE			FEMALE		
Information Measure	M^1	S.S.	Change	M^1	S.S.	Change
H(X)	2.9604	2.9604		2.9865	2.9865	
R.E.	98.68%			99.55%		
$H_x(Y)$	2.5022			2.5209		
R.E.	83.41%			84.03%		
CODE	0.4582			0.4656		
CODE EFFICIENCY	15.48%			15.59%		
H(Y)	3.3558	3.0396	0.3162	3.2605	3.0135	0.2470
$H_y(X)$	2.1068	2.8812	0.7744	2.2469	2.9595	0.7126
REAL	0.8536	0.0792	0.7744	0.7396	0.0270	0.7126
% REAL	15.63%	1.34%	14.29%	13.43%	0.45%	12.98%
LTM	0.3954	0.0792	0.3162	0.2740	0.0270	0.2470
% LTM	46.32%			37.05%		
H(X,Y)	5.4626	5.9208	0.4582	5.5074	5.9730	0.4656
NOISE	4.6090	5.8416	1.2326	4.7678	5.9460	1.1782
% NOISE	84.37%	98.66%	14.29%	86.57%	99.55%	12.98%
NOISE in X	71.17%	97.32%	26.15%	75.24%	99.10%	23.86%
NOISE in Y	74.56%	97.39%	22.83%	77.32%	99.10%	21.78%
Cells Occupied	58	64		55	64	
% Occupancy	90.63%			85.94%		
Log_2 N	5.8580	6.0000		5.7814	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.41526666			0.40013664		
M^2	0.17244640			0.16010933		
M^4	0.02973776			0.02563500		
M^{16}	0.00088433			0.00065715		
M^{256}	0.00000078			0.00000043		

TABLE X

A SUMMARY OF INFORMATION VALUES CALCULATED ACCORDING TO RACE FOR UNSUCCESSFUL STUDENTS IN GRADE 8

	NEGRO			CAUCASIAN		
Information Measure	M^1	S.S.	Change	M^1	S.S.	Change
H(X)	2.9873	2.9873		2.9799	2.9799	
R.E.	99.58%			99.33%		
$H_x(Y)$	2.5525			2.4657		
R.E.	85.08%			82.19%		
CODE	0.4348			0.5142		
CODE EFFICIENCY	14.55%			17.26%		
H(Y)	3.3055	3.0127	0.2928	3.2892	3.0201	0.2691
$H_y(X)$	2.2343	2.9619	0.7276	2.1564	2.9397	0.7833
REAL	0.7530	0.0254	0.7276	0.8235	0.0402	0.7833
% REAL	13.59%	0.43%	13.16%	15.12%	0.67%	14.45%
LTM	0.3182	0.0254	0.2928	0.3093	0.0402	0.2691
% LTM	42.26%			37.56%		
H(X,Y)	5.5398	5.9746	0.4348	5.4456	5.9598	0.5142
NOISE	4.7868	5.9492	1.1624	4.6221	5.9196	1.2975
% NOISE	86.41%	99.57%	13.16%	84.88%	99.33%	14.45%
NOISE in X	74.79%	99.15%	24.36%	72.36%	98.65%	26.29%
NOISE in Y	77.22%	99.16%	21.94%	74.96%	98.67%	23.71%
Cells Occupied	58	64		54	64	
% Occupancy	90.63%			84.38%		
Log_2 N	5.8580	6.0000		5.7549	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.39405924			0.43388196		
M^2	0.15528268			0.18825356		
M^4	0.02411271			0.03543940		
M^{16}	0.00058142			0.00125595		
M^{256}	0.00000034			0.00000158		

TABLE XI

A SUMMARY OF INFORMATION VALUES CALCULATED ACCORDING TO SEX AND RACE FOR UNSUCCESSFUL STUDENTS IN GRADE 8

	MALE-NEGRO			MALE-CAUCASIAN		
Information Measure	M^1	S.S.	Change	M^1	S.S.	Change
H(X)	2.9344	2.9344		2.9573	2.9573	
R.E.	97.81%			98.58%		
$H_x(Y)$	2.4217			2.3989		
R.E.	80.72%			79.96%		
CODE	0.5127			0.5584		
CODE EFFICIENCY	17.47%			18.88%		
H(Y)	3.3332	3.0656	0.2676	3.3290	3.0427	0.2863
$H_y(X)$	2.0229	2.8032	0.7803	2.0272	2.8719	0.8447
REAL	0.9115	0.1312	0.7803	0.9301	0.0854	0.8447
% REAL	17.02%	2.24%	14.78%	17.36%	1.44%	15.92%
LTM	0.3988	0.1312	0.2676	0.3717	0.0854	0.2863
% LTM	43.75%			39.96%		
H(X,Y)	5.3561	5.8688	0.5127	5.3562	5.9146	0.5584
NOISE	4.4446	5.7376	1.2930	4.4261	5.8292	1.4031
% NOISE	82.98%	97.76%	14.78%	82.64%	98.56%	15.92%
NOISE in X	68.94%	95.53%	26.59%	68.55%	97.11%	28.56%
NOISE in Y	72.65%	95.72%	23.07%	72.06%	97.19%	25.13%
Cells Occupied	54	64		53	64	
% Occupancy	84.38%			82.81%		
Log_2 N	5.7549	6.0000		5.7279	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.43261626			0.46241104		
M^2	0.18715683			0.21382397		
M^4	0.03502768			0.04572069		
M^{16}	0.00122694			0.00209038		
M^{256}	0.00000151			0.00000437		
Error Limit Input	1.4505	1.0468	0.4037	1.4588	1.0297	0.4291

TABLE XI (continued)

Information Measure	FEMALE-NEGRO M^1	S.S.	Change	FEMALE-CAUCASIAN M^1	S.S.	Change
H(X)	2.9733	2.9733		2.9787	2.9787	
R.E.	99.11%			99.29%		
$H_x(Y)$	2.4339			2.3189		
R.E.	81.13%			77.30%		
CODE	0.5394			0.6598		
CODE EFFICIENCY	18.14%			22.15%		
H(Y)	3.3475	3.0267	0.3208	3.2958	3.0213	0.2745
$H_y(X)$	2.0597	2.9199	0.8602	2.0018	2.9361	0.9343
REAL	0.9136	0.0534	0.8602	0.9769	0.0426	0.9343
% REAL	16.90%	0.90%	16.00%	18.44%	0.72%	17.72%
LTM	0.3742	0.0534	0.3208	0.3171	0.0426	0.2745
% LTM	40.96%			32.46%		
H(X,Y)	5.4072	5.9466	0.5394	5.2976	5.9574	0.6598
NOISE	4.4936	5.8932	1.3996	4.3207	5.9148	1.5941
% NOISE	83.10%	99.10%	16.00%	81.56%	99.28%	17.72%
NOISE in X	69.27%	98.20%	28.93%	67.20%	98.57%	31.37%
NOISE in Y	72.71%	98.24%	25.53%	70.36%	98.59%	28.23%
Cells Occupied	55	64		49	64	
% Occupancy	85.94%			76.56%		
Log_2 N	5.7814	6.0000		5.6147	6.0000	
Variety	8			8		
Adjusted CODE M^1	0.46356036			0.50514288		
M^2	0.21488821			0.25516933		
M^4	0.04617694			0.06511139		
M^{16}	0.00213231			0.00423949		
M^{256}	0.00000455			0.00001797		
Error Limit Input	1.4435	1.0182	0.4253	1.4878	1.0143	0.4735

TABLE XII

INFORMATION PROCESSED IN LONG AND SHORT TERM MEMORIES BY STUDENTS SOLVING THE PARALLEL CIRCUIT PROBLEM

Grade	Outcome	Group	% Information Processed In: Short Term Memory	% Information Processed In: Long Term Memory
2	Unsuccessful	Total	92.01%	7.99%
		Male	85.63%	14.37%
		Female	85.53%	14.47%
		Negro	88.90%	11.10%
		Caucasian	87.61%	12.39%
		Male, Negro	82.33%	17.67%
		Male, Caucasian	82.65%	17.35%
		Female, Negro	89.79%	10.21%
		Female, Caucasian	73.91%	26.09%
8	Unsuccessful	Total	93.11%	6.89%
		Male	83.31%	16.69%
		Female	91.03%	8.97%
		Negro	92.61%	7.39%
		Caucasian	88.50%	11.50%
		Male, Negro	75.25%	24.75%
		Male, Caucasian	81.32%	18.68%
		Female, Negro	87.51%	12.49%
		Female, Caucasian	88.16%	11.84%
8	Successful	Total	81.49%	18.51%
		Male	82.01%	17.99%
		Female	74.80%	25.20%
		Negro	63.57%	36.43%
		Caucasian	80.29%	19.71%
		Male, Negro	71.91%	28.09%
		Male, Caucasian	71.90%	28.10%
		Female, Negro	61.64%	38.36%
		Female, Caucasian	77.11%	22.89%

TABLE XIII

DIFFERENCES BETWEEN AMOUNTS OF INFORMATION PROCESSED IN LONG TERM MEMORIES OF SUCCESSFUL AND UNSUCCESSFUL STUDENTS IN GRADE 8

Group	Percentage Point Difference (% LTM for Successful - % LTM for Unsuccessful)
Total	11.62
Male	1.3
Female	16.23
Negro	29.04
Caucasian	8.21
Male, Negro	3.34
Male, Caucasian	9.42
Female, Negro	25.87
Female, Caucasian	11.05

TABLE XIV

SIGNIFICANCES OF DIFFERENCES BETWEEN AMOUNTS OF INFORMATION PROCESSED IN SHORT TERM MEMORIES OF SUCCESSFUL AND UNSUCCESSFUL STUDENT GROUPS IN GRADES 2 AND 8

Grade	Grouped According To	Degrees Of Freedom	Chi-Square Value
2	Sex	1	0.00
	Race	1	0.00
	Sex and Race	3	1.54
8	Outcome	1	0.78
	Outcome and Sex	1	0.68
	Outcome and Race	1	1.56
	Outcome, Sex and Race	3	1.88

TABLE XV

SIGNIFICANCES OF DIFFERENCES BETWEEN AMOUNTS OF INFORMATION PROCESSED IN LONG TERM MEMORIES OF SUCCESSFUL AND UNSUCCESSFUL STUDENT GROUPS IN GRADES 2 AND 8

Grade	Grouped According To	Degrees Of Freedom	Chi-Square Value
2	Sex	1	0.00
	Race	1	0.07
	Sex and Race	3	7.10
8	Outcome	1	5.32*
	Outcome and Sex	1	3.51
	Outcome and Race	1	3.86*
	Outcome, Sex and Race	3	5.88

* Significant at the 5% level

TABLE XVI

SIGNIFICANCES OF DIFFERENCES IN PROPORTIONS OF USEFUL INFORMATION IN THE TRANSMISSION CHANNELS OF SUCCESSFUL AND UNSUCCESSFUL STUDENT GROUPS IN GRADES 2 AND 8

Grade	Grouped According To	Degrees Of Freedom	Chi-Square Value
2	Sex	1	0.98
	Race	1	1.15
	Sex and Race	3	8.23*
8	Outcome	1	0.12
	Outcome and Sex	1	1.19
	Outcome and Race	1	0.35
	Outcome, Sex and Race	3	1.24

TABLE XVII

SIGNIFICANCES OF DIFFERENCES ACCORDING TO RACE AT STEADY STATE CONDITIONS IN PROPORTIONS OF USEFUL INFORMATION IN THE TRANSMISSION CHANNELS OF SUCCESSFUL AND UNSUCCESSFUL STUDENT GROUPS IN GRADES 2 AND 8

Grade	Grouped According To	Degrees Of Freedom	Chi-Square Value
2	Sex	1	0.36
	Race	1	1.88
	Sex and Race	3	29.92*
8	Outcome	1	4.28*
	Outcome and Sex	1	5.66*
	Outcome and Race	1	2.24
	Outcome, Sex and Race	3	3.86

* Significant at the 5% level

TABLE XVIII

CHANNEL LIMITS FOR ERROR CAPACITY

Grade	Outcome	Group	Channel Limits For Error Capacity In M^1	S.S.	Change
2	Unsuccessful	Male, Negro	1.2507	1.0176	0.2331
		Male, Caucasian	1.7729	1.0464	0.7265
		Female, Negro	1.5424	1.0147	0.5277
		Female, Caucasian	1.9376	1.0787	0.8589
8	Successful	Male, Negro	1.7953	1.0665	0.7288
		Male, Caucasian	1.4252	1.0524	0.3730
		Female, Negro	1.6331	0.9524	0.6807
		Female, Caucasian	1.8157	1.0484	0.7673
8	Unsuccessful	Male, Negro	1.4505	1.0468	0.4037
		Male, Caucasian	1.4588	1.0297	0.4291
		Female, Negro	1.4435	1.0182	0.4253
		Female, Caucasian	1.4878	1.0143	0.4735

TABLE XIX

SIGNIFICANCES OF DIFFERENCES BETWEEN NUMBERS OF EIGHTH GRADE STUDENTS WHO SUCCESSFULLY AND UNSUCCESSFULLY COMPLETED THE PARALLEL CIRCUIT PROBLEM

Students Grouped According To	Degrees Of Freedom	Chi-Square Value
Outcome	1	3.2666
Outcome and Sex	1	3.8668
Outcome and Race	1	3.8668
Outcome, Sex and Race	3	4.5332

TABLE XX

MEANS FOR NUMBER OF CONNECTIONS MADE
BY SUCCESSFUL AND UNSUCCESSFUL STUDENT GROUPS IN GRADES 2 AND 8

Grade	Outcome	Group	# Students in Group	Number of Connections	Mean	Variance	Standard Deviation
2	Unsuccessful	Total	58	1075	18.53	341.87	18.49
		Male	28	652	23.29	515.77	22.71
		Female	30	423	14.10	138.82	11.78
		Negro	29	476	16.41	102.31	10.11
		Caucasian	29	599	20.66	572.44	23.93
		Male, Negro	14	265	18.93	129.49	11.38
		Male, Caucasian	14	387	27.64	864.09	29.40
		Female, Negro	15	211	14.07	65.52	8.09
		Female, Caucasian	15	212	14.13	212.12	14.56
8	Successful	Total	23	658	28.61	504.41	22.46
		Male	13	391	30.08	551.92	23.49
		Female	10	267	26.70	436.21	20.89
		Negro	10	240	24.00	509.20	22.57
		Caucasian	13	418	32.15	471.82	21.72
		Male, Negro	6	195	32.50	653.92	25.57
		Male, Caucasian	7	196	28.00	455.14	21.33
		Female, Negro	4	45	11.25	21.19	4.60
		Female, Caucasian	6	222	37.00	447.67	21.16
8	Unsuccessful	Total	37	2166	58.54	1162.14	34.09
		Male	17	1056	62.12	1404.22	37.47
		Female	20	1110	55.50	936.25	30.60
		Negro	20	984	49.20	943.26	30.71
		Caucasian	17	1182	69.53	1196.25	34.59
		Male, Negro	9	396	44.00	818.44	28.61
		Male, Caucasian	8	660	82.50	1278.50	35.76
		Female, Negro	11	588	53.45	1005.15	31.70
		Female, Caucasian	9	522	58.00	840.67	28.99

TABLE XXI

T-TEST COMPARISONS OF MEAN NUMBER OF CONNECTIONS MADE BY SUCCESSFUL AND UNSUCCESSFUL STUDENT GROUPS IN GRADES 2 AND 8

Grade	Outcome	Group	Degrees of Freedom	t
2	Unsuccessful	Male-Female	56	1.92
		Negro-Caucasian	56	-0.87
		Male, Negro-Male, Caucasian	28	-1.00
		Female, Negro-Female, Caucasian	28	-0.01
8		Unsuccessful-Successful	58	3.67*
8	Successful	Male-Female	21	0.34
		Negro-Caucasian	21	-0.84
		Male, Negro-Male, Caucasian	11	0.32
		Female, Negro-Female, Caucasian	8	-2.14*
8	Unsuccessful	Male-Female	35	0.58
		Negro-Caucasian	35	-1.84
		Male, Negro-Male, Caucasian	15	-2.31*
		Female, Negro-Female, Caucasian	18	-0.31

*Significant at the 5% level

APPENDIX II

DEFINITIONS OF INFORMATION THEORETIC MEASURES*

Symbol	Term	Definition
H(X)	Actual Information	The entropy or information of the source of messages, or input message of memory.
H (Max.)	Maximum Information	The information in any message, if every message has an equal probability of occurring.
R. E.	Relative Entropy	The information in the choice of the sender, or the freedom of choice of the sender.
RED.	Redundancy	The information or uncertainty due to the statistical nature of the set of events.
H_X (Y)	Conditional Information	The uncertainty or information in second or received messages if the source message or first message were known. Also regarded as noise to be filtered from input memory message.
CODE	Code or Chunk	The filtering-out process, or the signal processed in the memory, for relating input to operation for new information retrieval.
CODE EFFICIENCY	Filtering or Chunking	The amount of H (X) input in the code signal, or portion of input, H (X), used for a match in long term memory retrieval search.
H (Y)	Independent Information of Second Event	The information in the received message or the memory message output, and independent of the input message; if it contains noise.
REAL	Useful Information	The amount of information which is not spurious, or the CODE message signal plus that retrieved from the long term memory (as LTM).
% REAL	Percent Useful Information	The proportion of a transmission channel which is useful or non-spurious information, or the proportion of information shared by continuous messages which is meaningful.

* The entries are not alphabetical, but are as the calculation procedures are executed for the treatment of event data. The expressions and definitions are taken in part from Shannon (3), Moser (1), and Felen (2).

Symbol	Term	Definition
H_y (X)	Equivocation	The amount of error-correcting information in a channel, or the initial match identification in the memory, and used to determine whether or not an input message will be processed for long term memory retrieval operations.
NOISE	Noise	The portion of a transmission channel which is spurious, or in the memory it is the "non-useful" information for new information retrieval operations.
% NOISE	Noise	The phase-space portion of a transmission channel which is spurious, errorful, or which is not useful information.
H (X,Y)	Shared Information	The amount of information shared by consecutive X and Y messages, or in the memory it is used as a control mechanism for checking the input information with the subvocal output information.
LTM	Long Term Memory Information	The amount of information retrieved from the long term memory store, in a channel represents the end product of the subsitizing (11) of chunks being related to useful information (REAL).
	Noise in X and Noise in Y	The amount of spurious information in the input and output messages in a transmission channel or memory model.
	REAL in X and REAL in Y	The amount of useful information in the input and output messages (see above).
BIT	Bits	The contraction of the words binary digit. A unit of information, or uncertainty and one bit represents the amount of information in the choice between two equally probable events.
C.C.	Channel Capacity	The capacity of a communication channel is equal to the information rate of transmission, or bits per discrete event being transmitted.
H	Information	The logarithmic measure of the improbability of an event in a given situation.
	Markoff Chain	A special stochastic process (12) in which the probabilities are dependent on preceding events.
	Steady State	A condition in a finite Markoff Chain where the probability of a given state will be almost independent of the initial state at time 0 (12).

Symbol	Term	Definition
S.S.H(Y)	Steady State Independent Information	The information in an event when it has no dependence on the event preceding it.
	Strength of Dependence	The numerical quality of dependence between X and Y events in a Markovian Chain (12).

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